REGRESSION RESULTS ON THE EFFECTS OF TECHNOLOGY ON MIGRANT SCHOOL STUDENTS

A Thesis

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By

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ABSTRACT

A well-developed educational program helps to improve an individual's prosperity and overall happiness. As governments and academics attempt to change the problem with underdeveloped educational programs in rural areas, a key source they reach out to is improvements in technology within the classroom. However, as technology further penetrates the educational system, scholars are paying more attention to technological learning methods and to the technology used for learning, such as computers, mobile phones and tablet technology. This thesis will investigate in which areas—both grade and subject—tablet PCs have the biggest impact on the education in rural China.

BIOGRAPHICAL SKETCH

Walter Rose graduated from the Cornell University Charles H. Dyson School of Applied Economics and Management—a part of the S.C. Johnson College of Business—in 2017 (completed in 3 years). Immediately after completing his undergraduate education at Cornell University, Walter entered the Master's program at Cornell, which he completed in May of 2018. His research concentration is financial economics. Walter was born and raised in the Greater Boston area where he lived with his parents, his older sister and younger brother.

DEDICATION

Walter Rose's thesis is dedicated to those that supported him and inspired him throughout his academic and personal development. First and foremost to his family. His loving Father, Steven Rose, and thoughtful Mother, Sally Rose, who both taught him the importance of using education as a key to open the doors of your life. To his intellectual and funny siblings, Emily and Henry, who will continue to be his best friends that will always appreciate an inside joke or philosophical conversation. To his friends who always pushed him to be the best he could be throughout his educational journey: Stuart Wang, Charlie Liao, Louis Liu, and Misha Rawal. All of whom constantly provide inspiration and support throughout many stressful and sleepless nights, reminding him that a difficult problem isn't one to hide from, but rather confront with supporting and trustworthy people by your side.

ACKNOWLEDGEMENTS

I would like to thank and acknowledge my research professor, Dr. David Ng, for giving me the valuable experience of being his research assistant for my entire time at Cornell. Having Dr. Ng as my mentor has contributed significantly to my appreciation of what is involved in academic research.

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1. Introduction and Background

As developing countries focus on improvements within their educational system in order to help grow the economy, the debate continues regarding how to effectively solve the problems surrounding educational quality (Carrillo, Onofa, & Ponce, 2010). Using computers is a useful tool that governments are using in order to increase the overall quality of a countries educational system. During the 1990s, as the Internet developed, computers were more widely used within the educational system. Even within developing countries with limited resources and money, computers are becoming a tool used to help areas where qualified teachers are scarce (Angrist and Lavy, 2002).

Many countries have introduced computers into schools. For example, in Australia during 1999 and 2000, the government invested about 4.3 billion dollars on educational technology (Hall & Higgins, 2005). In addition, the US spends more than 5 billion dollars annually on computers within schools (MDR 2004). Also, in 2012, the Thai Government started the "One Tablet PC Per Child" program that distributed approximately 800,000 tablets to first graders nationwide (Pruet, Ang & Farzin, 2014).

In order to analyze the issue of tablets technology within schools, Professor Ng at Cornell University and The Youth Foundation of Hong Kong conducted a research project called *Bridging the Digital Divide: A Knowledge Enrichment Program for Migrant Children*, which was conducted with students from a primary school in Beijing, China. This research is dealing with migrant children within the Beijing region. The issue with the school system is that there are only thirty-four teachers in the entire region, many of whom are not qualified. In addition, the school does not have the monetary resources required to buy the necessary supplies for a high quality educational system. The students who participated in this project were between grade four and six.

There were 865 students in the schools who were either part of the control group (without tablet) or part of the experimental group (with tablet). However, there are only thirty-four teachers in the entire school.

2. Literature Review

Many studies have attempted to analyze the benefits of computer technology within the classroom, and many have found that using computers can be particularly beneficial with math learning. For example, in 2009, Barrow et al. found that computers that helped students with pre-algebra and algebra in the United States have a positive effect on test scores. In addition, in 2005, Banerjee et al. found that computers can improve mathematics scores for fourth-graders in Vadodara, India.

In 2013, Fairlie and Robinson considered many factors beyond merely computers being present or not. These factors included, immigrant status, parent's education, gender, ethnicity, and language to analyze the effects of home computers on children's academic achievement. The results were the following regression:

$$Y_i = \beta_{pc} * D_{ip} * C_i + \beta_{pt} * D_{ip} * T_i + \delta X_i + \varepsilon_i$$

In the regression, D_{ip} indicates whether individual i is in the pth percentile of the pre-treatment GPA distribution. C_i represents the control group, while T_i represents the treatment group. Therefore, β_{pc} and β_{pt} are estimates of the relationship between pre-treatment GPA and post-treatment GPA within the control group and the treatment groups. The difference between β_{pt} -β_{pc} gives an estimate of the treatment effect at the pth percentile. X_i is a minimal set of controls.

During this thesis, we ran similar regressions to analyze the effects of tablet technology on 4^{th}, 5^{th}, and 6^{th} graders within Chinese, English and Math classes. These students came from similar backgrounds and economic status, all being within the same migrant rural area of China.

3. Methodology, Participants and Data Sources

3.1 Overall Background

The research project *Bridging the Digital Divide: A Knowledge Enrichment Program for Migrant Children* was conducted by professor David T. Ng (my advisor) at Cornell University and The Youth Foundation of Hong Kong, with the aim of improving migrant children's academic test scores and learning abilities by using tablet PCs as their learning tools.

The first pilot program took place from the end of April 2013 to early July 2013, the second pilot program lasted from September 2013 to January 2014, and the third pilot program took place from February 2014 to July 2014. I was fortunate to be a research assistant for all three pilot programs. The participants totaled more than 800 migrant children and were all enrolled in grade four to grade six in the same primary school during all the three pilots.

3.2 Pilot 1

In the first pilot program, both the experimental and control groups were only comprised of migrant children in grade six of which there were three classes. Each class had between 32 to 42 students, totaling to 109 students. Those students to whom the research assistants randomly distributed tablet PCs became or comprised the experiment group. Each student could use the tablet PC, both at home and at school, for 2 or 3 days per week. To dissuade students from using the tablet PCs to play games or to search websites unrelated to learning, the research assistants installed some learning applications on the tablet PCs and imposed restriction on internet use. The students who did not receive the tablet PCs were members of the control group.

In April 2013, before the experiment group received their tablet PCs, the researchers gave both experiment and control groups a standardized mathematics test and the test scores were used as baseline scores in Pilot 1. In July 2013, the researchers conducted another standardized

mathematics exam as final test scores for Pilot 1 on students in both groups. Both the baseline and final standardized mathematics exam followed the same format with 33 questions (one point per question), and they had a similar level of difficulty.

3.3 Pilot 2

Pilot 2 program conducted from September 2013 to January 2014, was more extensive with an increased number of students totaling to 195 coming from grades four, five and six. Still the researchers randomly selected students to be in the two groups. Of the 195 students, 55 were in the experiment group and the remaining 140 were in the control group.

3.4 Pilot 3

In the third pilot program, from February 2014 to July 2014, 202 students took part in the research program. The researchers conducted the project using a method similar to the method applied during the first and second pilot programs.

3.5 Data Sources

There are three main sources of data. Firstly, standardized mathematics test scores in all three pilot periods. Secondly, standardized English test scores in Pilot 3. Thirdly, standardized Chinese test scores in Pilot 3.

All three data sources are broken into six standardized test score sections:

1) Baseline in 1st pilot period
2) Final in 1st pilot period
3) Baseline in 2nd pilot period
4) Final in 2nd pilot period
5) Baseline in 3rd pilot period
6) Final in 3rd pilot period

4. Results

Based on the information from the regression models that are presented within the Tables Section of the paper, education production equations are built as follows:

4.1: Difference in Score because of Tablets

(1) All Grades and All Subjects Score Difference = $\alpha + \beta 1(Tablet_i)$

a) Based on the data from Table 2

b) Comparing the experiment group ($Tablet_i$ =1) and the control group ($Tablet_i$ =0) and not taking into consideration subject or grade, the formula above (Formula 1) shows that the experimental group had an average improvement of 3.1 between their final standardized test scores and baseline standardized score. This data factor was significant at a 1% significance level.

4.2: Difference in Score by Grade

(2) All Subjects Score Difference = $\alpha + \beta 1(Tablet_i) + \beta 2(Grade4_i) + \beta 1(Grade5_i)$

a) Based on the data from Table 3

b) Comparing the experiment group ($Tablet_i$ =1) and the control group ($Tablet_i$ =0) difference in scores between their final standardized test scores and baseline standardized score by grade, while not taking into consideration subject, the formula above (Formula 2) shows that the experimental group had an average improvement of 1.9711. The regression uses Grade 4, 5, and 6 as variables to regress against within all data from all subjects with Grade 6 coefficient being represented with α. This data factor was significant at a 5% significance level.

4.3: Difference in Math Score

(3) All Grades Math Score Difference = α + $\beta 1(Tablet_i)$ + $\beta 2(Math\_Grade4_i)$ + $\beta 1(Math\_Grade5_i)$

a) Based on the data from Table 4

b) Comparing the experiment group ($Tablet_i$ =1) and the control group ($Tablet_i$ =0) difference in Math scores between their final standardized test scores and baseline standardized score by grade, the formula above (Formula 3) shows that the experimental group had an average improvement of 6.0909. The regression uses Grade 4, 5, and 6 as variables to regress against within all Math Scores with Grade 6 coefficient being represented with α. This data factor was significant at a 1% significance level.

(4) Math Score Difference = $\alpha + \beta 1(Tablet_i) + \beta 2(Math_i) + \beta 3(Tablet_i)(Math_i)$

a) Based on the data from Table 5

b) Comparing the experiment group ($Tablet_i$ =1) and the control group ($Tablet_i$ =0) difference in Math scores between their final standardized test scores and baseline standardized score, the formula above (Formula 4) shows that the experimental group had an average improvement of 3.753 within Math Scores because of tablet technology. This data factor was significant at a 10% significance level

(5) Grade 6 Math Score Difference = $\alpha + \beta 1(Tablet_i) + \beta 2(Math_i) + \beta 3(Math\_Grade6_i) + \beta 4(Tablet_i)(Math\_Grade6_i) + \beta 5(Tablet_i)(Math_i)$

a) Based on the data from Table 6

b) Comparing the experiment group ($Tablet_i$ =1) and the control group ($Tablet_i$ =0) difference in Math scores between their final standardized test scores and baseline

standardized score, the formula above (Formula 5) shows Grade 6 students in Math (regardless of tablet or no tablet) will have a positive improvement from the final exam score compared to the baseline score. This improvement will be 3.6576. However, if the Math students in Grade 6 also have a tablet, then the improvement is much larger at 11.6221. This data factor was significant at a 1% significance level.

4.4: Difference in Score by Subject

(6) All Grades Score Difference $= \alpha + \beta 1(Tablet_i) + \beta 2(English_i) + \beta 1(Math_i)$

a) Based on the data from Table 7

b) Comparing the experiment group ($Tablet_i$ =1) and the control group ($Tablet_i$ =0) difference in scores between their final standardized test scores and baseline standardized score by subject, while not taking into consideration grade, the formula above (Formula 6) shows that the experimental group had an average improvement of 12.8684. The regression uses the three subjects (English, Chinese, and Math) as variables to regress against with Chinese coefficient being represented with α. This data factor was significant at a 1% significance level.

4.5: Overall Results

When looking at the use of tablet technology in the educational school system in rural China, some subjects and grades are more responsive to the positive impact made by the introduction of technology into the classroom. When looking at the overall impact of tablet technology, Table 2 show how tablet technology has a positive impact that is statistically significant and, on average, will increase a student's score by 3.1 points from the baseline score to the final score. The point of this study and research is to provide further investigative analysis to see which subjects

(Chinese, Math, and English) and which grades (4^{th}, 5^{th}, and 6^{th}) have the greatest impact on the scores when tablet technology is introduced into the classroom.

When looking at the differences in scores from the baseline exam to the final exam, only English and Chinese scores are present in Pilot 3. Therefore, there is significantly less data for those subjects than for math, which is present in all three pilots. As shown in Table 8 and Figure 1, English scores improve on average 0.77 more for the experiment group compared to the control group. Therefore, the amount of improvement is not that drastic for English (by looking at all 3 grades). As shown in Table 9 and Figure 2, Chinese scores improve on average 1.01 more for the experiment group compared to the control group. Therefore, the amount of improvement is not that drastic for Chinese (by looking at all 3 grades). As shown in Table 10 and Figure 3, math scores improve on average 4.64 more for the experiment group compared to the control group. Therefore, out of the three subjects, student improvement in math is the most considerable when tablet technology is introduced into the classroom (by looking at all 3 grades).

When looking at the differences in scores from the baseline exam to the final exam, based on the three grades, grade 6 shows the most considerable improvement when tablet technology is introduced into the classroom (by looking at data from all 3 subjects). As shown in Table 11, Grade 4 scores decrease by 3.42 when tablet technology is introduced into the classroom. The decrease may result from tablets being a distraction instead of a benefit for the students. As shown in Table 12, Grade 5 scores decrease by 2.10 when tablet technology is introduced into the classroom. Also, as shown in Table 13 and Figure 4, Grade 6 scores increase by 8.34 when tablet technology is introduced into the classroom. The increase means that there is a positive trend with students when they move up in grade level as they get more benefit from tablet technology. This could be because

students are concentrating more on the academic material and information being taught using the technology instead of being distracted by the technology.

4.6: Variables

The above equations are used to find the difference in exam scores from the Baseline score to the Final score based on different factors such as Subject (Math, Chinese, or English), Grade (4^{th}, 5^{th}, or 6^{th}), and Tablet (Yes to have the tablet or No to not having the tablet) using the test scores for student *i* throughout the various pilots.

$Tablet_i$ is a dummy variable for whether student *i* is in experiment group and assigned to a tablet PC for learning (Tablet=1) or in control group (Tablet=0).

$Grade4_i$ *is* a dummy variable for whether the student *i* comes from Grade 4, with Grade 4 = 1 and Grade 5 or 6 = 0.

$Grade5_i$ is a dummy variable for whether the student *i* comes from Grade 5, with Grade 5 = 1 and Grade 4 or 6 = 0.

$Chinese_i$ is a dummy variable for whether the student *i* comes from Chinese class, with the subject being Chinese = 1 and if the subject is Math or English then 0.

$Math_i$ is a dummy variable for whether the student *i* comes from Math class, with the subject being Math = 1 and if the subject is Chinese or English then 0.

Math_Grade4$_i$ is a dummy variable for whether the student *i* comes from Grade 4 when dealing with only Math scores, with Grade 4 = 1 and Grade 5 or 6 = 0.

Math_Grade5$_i$ is a dummy variable for whether the student *i* comes from Grade 5 when dealing with only Math scores, with Grade 5 = 1 and Grade 4 or 6 = 0.

Math_Grade6$_i$ is a dummy variable for whether the student *i* comes from Grade 6 when dealing with only Math scores, with Grade 6 = 1 and Grade 4 or 5 = 0.

5. Conclusion

Overall, the educational use of tablet technology helps students in math more than English or Chinese. Tablet technology also helps students more dramatically as they increase in grade level, and correspondingly as student ages increase. Therefore, if school systems or governments are attempting to best utilize their resources and monetary spending on tablet technology, it is our recommendation that the greatest positive affect on student education will result from focusing on mathematical subjects with students in higher grades.

Tables

For Tables 2-7, the t-stat is reported in parentheses beneath the variable coefficients, **, and * denote statistical significance at the 1%, and 5% levels, respectively.

Table 1: Overall Breakdown

		Group Size
All	control group(tablet=0)	443
	test group(tablet=1)	422
Grade 4	control group(tablet=0)	150
	test group(tablet=1)	112
Grade 5	control group(tablet=0)	132
	test group(tablet=1)	99
Grade 6	control group(tablet=0)	161
	test group(tablet=1)	211
Chinese	control group(tablet=0)	101
	test group(tablet=1)	103
English	control group(tablet=0)	101
	test group(tablet=1)	103
Math	control group(tablet=0)	241
	test group(tablet=1)	216

Table 2: Regression Results with Difference in all Grade Scores (All Pilots)

	Intercept	Tablet
Positive Score Improvement	3.072	3.1
	(4.327)**	(3.05)*
N	865	865
Adjusted R-sq	0.009518	0.009518

Table 3: Multivariate Regression Results with Difference in Scores of all Subjects by Grade (All Pilots)

	Intercept	Tablet	Grade 4	Grade 5
Positive Score Improvement	8.3244	1.9711	-9.9957	-6.2683
	(8.957)**	(2.003)*	(-8.588)**	(-5.188)**
N	865	865	865	865
Adjusted R-sq	0.08892	0.08892	0.08892	0.08892

Table 4: Multivariate Regression Results with Difference in Math Scores by Grade (All Pilots)

	Intercept	Tablet	Grade 4	Grade 5
Positive Score Improvement	1.6119	6.0909	-12.5824	-6.9198
	(1.673)	(4.647)**	(-7.297)**	(-3.75)**
N	457	457	457	457
Adjusted R-sq	0.1301	0.1301	0.1301	0.1301

Table 5: Multivariate Regression Results with Difference in Math Scores of all Grades (All Pilots)

	Intercept	Tablet	Math	Tablet:Math
Positive Score Improvement	7.9876	0.8883	-9.0357	3.753
	(7.835)**	(0.619)	(-6.537)**	(1.900)
N	457	457	457	457
Adjusted R-sq	0.1301	0.1301	0.1301	0.1301

Table 6: Multivariate Regression Results with Difference in Math Scores for Grade 6 (All Pilots)

	Intercept	Tablet	Math	Math_Grade 6	Tablet:Math_Grade6	Tablet:Math
Positive Score Improvement	7.9869 (8.112)**	0.8883 (0.642)	-10.356 (-6.926)**	3.6576 (1.951)	11.6221 (4.317)**	-3.9105 (-1.686)
N	865	865	865	865	865	865
Adjusted R-sq	0.1334	0.1334	0.1334	0.1334	0.1334	0.1334

Table 7: Multivariate Regression Results with Difference in Scores of all Grades by Subject (All Pilots)

	Intercept	Tablet	English	Math
Positive Score Improvement	3.277 (2.94)**	2.8684 (2.949)**	7.4203 (5.243)**	-3.4878 (-2.897)**
N	865	865	865	865
Adjusted R-sq	0.09364	0.09364	0.09364	0.09364

Table 8: English Scores on Pilot 3

	Experiment	Control	Difference
Baseline Average	64.94417476	59.6039604	5.340214361
Final Average	77.47184466	71.36138614	6.110458522
Improvement Average	12.5276699	11.75742574	0.77024416

Table 9: Chinese Scores on Pilot 3

	Experiment	Control	Difference
Baseline Average	79.91747573	80.39108911	-0.473613381
Final Average	85.14174757	84.60891089	0.532836682
Improvement Average	5.224271845	4.217821782	1.006450062

Table 10: Math Scores on all Pilots

	Experiment	Control	Difference
Baseline Average	65.67644355	62.36313341	3.313310146
Final Average	69.269711	61.31504139	7.954669613
Improvement Average	3.593267445	-1.04809202	4.641359468

Table 11: Grade 4 Scores on all Pilots

	Experiment	Control	Difference
Baseline Average	73.6131466	58.49	15.123192
Final Average	70.8936147	59.187	11.70708
Improvement Average	-2.7195318	0.6966	-3.416112

Table 12: Grade 5 Scores on all Pilots

	Experiment	Control	Difference
Baseline Average	74.8398378	61.947	12.892478
Final Average	78.7870523	67.993	10.794325
Improvement Average	3.94721457	6.0454	-2.0981529

Table 13: Grade 6 Scores on all Pilots

	Experiment	Control	Difference
Baseline Average	63.7585093	70.036	-6.2775174
Final Average	75.6940974	73.631	2.0630401
Improvement Average	11.9355881	3.595	8.3405575

Figures

Figure 1: English Scores for Pilot 3

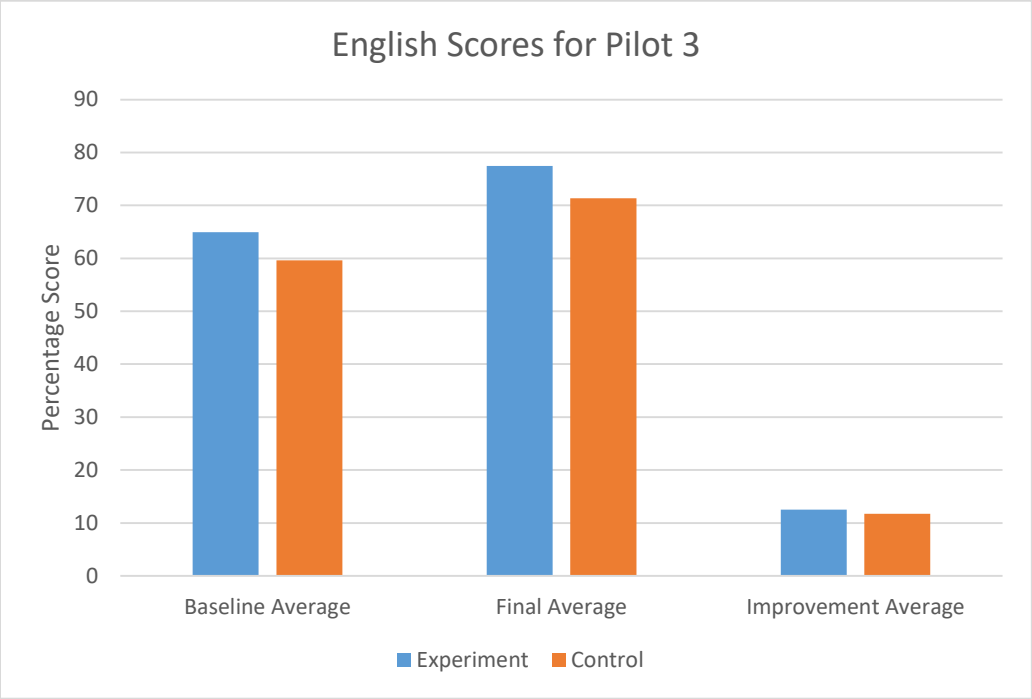

Figure 2: Chinese Scores for Pilot 3

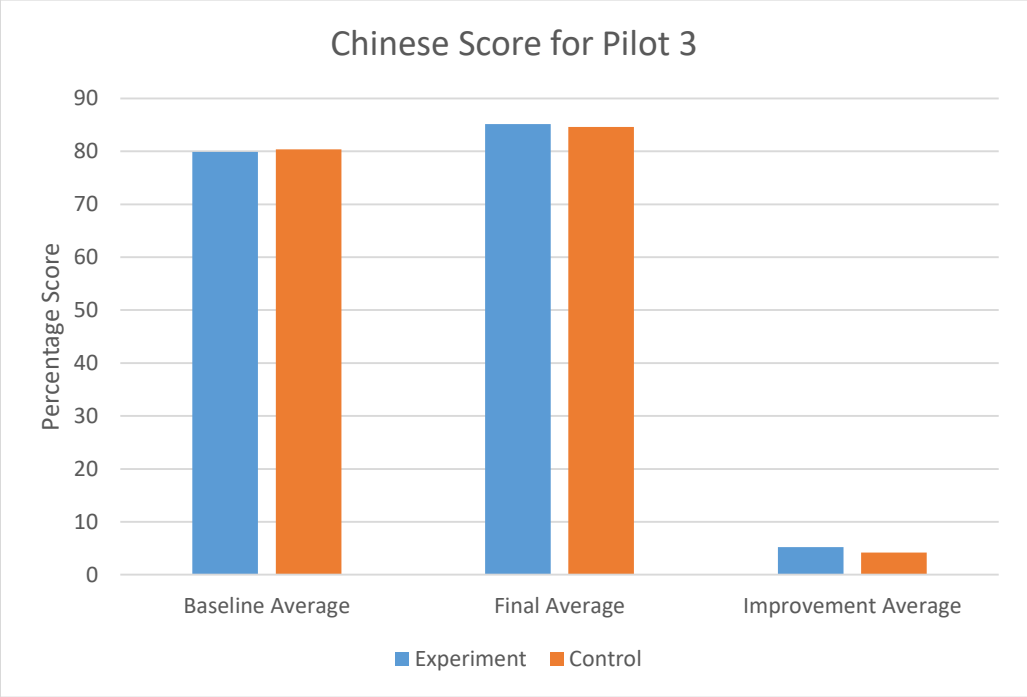

Figure 3: Math Scores for all Pilots

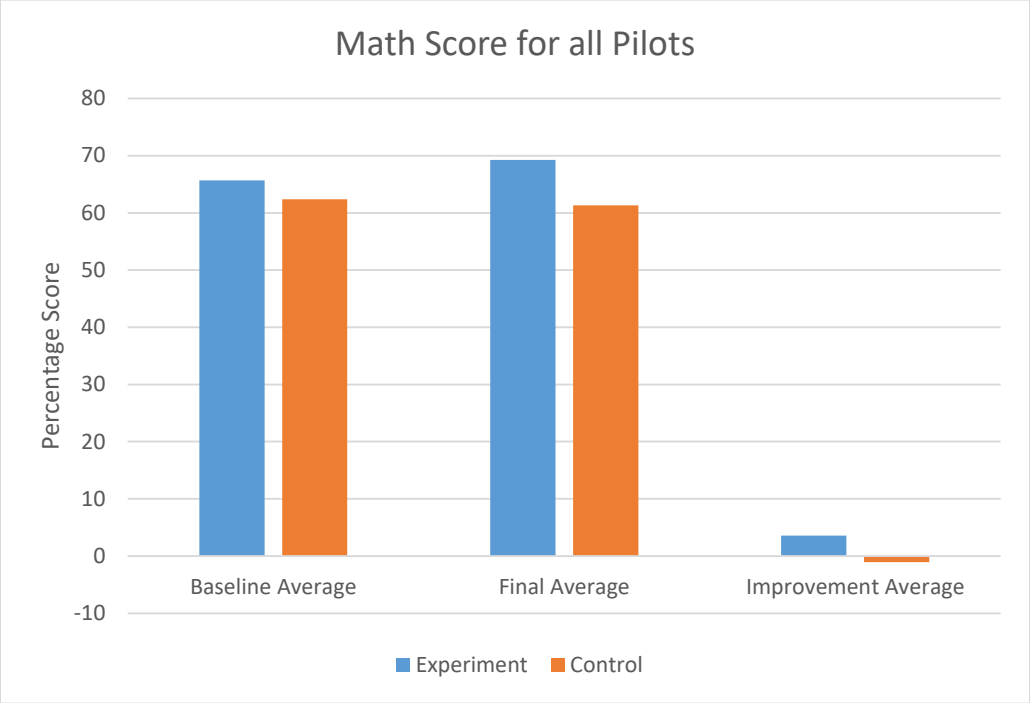

Figure 4: Grade 6 Scores for all Pilots

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